Q1.

A toy remote control speed boat is launched from one edge of a small pond and moves in a straight line across the pond's surface.

The boat's velocity, v m s^{-1}, is modelled in terms of time, t seconds after the boat is launched, by the expression

$$v = 0.9 + 0.16t - 0.06t^2$$

(a) Find the acceleration of the boat when $t = 2$

(3)

(b) Find the displacement of the boat, from the point where it was launched, when $t = 2$

(4)

(Total 7 marks)

Q2.

A car has an initial velocity of 1 m s^{-1}

The car is moving in a straight line.

The acceleration a m s^{-2} of the car at time t seconds is given by

$$a = 3kt^2 - 2kt + 1$$

where k is a constant.

When $t = 3$ the car has a velocity of 10 m s^{-1}

Show that $k = \frac{1}{3}$

(Total 4 marks)

Q3.

A particle, P, is moving along a straight line such that its acceleration a ms^{-2}, at any time, t seconds, may be modelled by

$$a = 3 + 0.2t$$

When $t = 2$, the velocity of P is k ms^{-1}

(a) Show that the initial velocity of P is given by the expression $(k - 6.4)$ ms^{-1}

(4)

(b) The initial velocity of P is one fifth of the velocity when $t = 2$

Find the value of k.

(2)

(Total 6 marks)

Q4.

A particle, P, is moving in a straight line with acceleration a m s^{-2} at time t seconds, where

$$a = 4 - 3t^2$$

(a) Initially P is stationary.

Find an expression for the velocity of P in terms of t.

(2)

(b) When $t = 2$, the displacement of P from a fixed point, O, is 39 metres.

Find the time at which P passes through O, giving your answer to three significant figures.

Fully justify your answer.

(5)
(Total 7 marks)

Q1.

	Marking Instructions	AO	Marks	Typical Solution
(a)	Differentiates to find expression for acceleration with at least one term correct. PI by -0.08 or 0.08	3.4	M1	$a = 0.16 - 0.12t$ $a = -0.08$ ms^{-2}
	Obtains a fully correct expression for acceleration. PI by -0.08	1.1b	A1	
	Finds their acceleration of the boat when $t = 2$ FT their expression for a Must have differentiated at least one term. Correct units must be stated.	3.2a	A1F	

(b)	Integrates v with at least one term correct. PI by 1.96	3.1b	M1	$s = \int v \mathrm{d}t$ $= \int 0.9 + 0.16t - 0.06t^2 \mathrm{d}t$ $s = 0.9t + 0.08t^2 - 0.02t^3 + c$ $s = 0$ when $t = 0$ so $c = 0$ $s = 0.9(2) + 0.08(4) - 0.02(8)$ Displacement = 1.96 m
	Obtains a fully correct integral. Condone omission of constant PI by 1.96	1.1b	A1	
	Substitutes $t = 0$ and $t = 2$ into their expression for s Must have integrated at least one term. PI by 1.96	1.1a	M1	
	Obtains displacement = 1.96 m Condone omission of units	1.1b	A1	
				Total 7 marks

Q2.

Marking Instructions	AO	Marks	Typical Solution
Integrates a with at least one term correct.	3.4	M1	$v = \int a \, \mathrm{d}t$ $v = kt^3 - kt^2 + t + c$ $v = 1$ when $t = 0$ then $c = 1$ $v = 10$ and $t = 3$ $10 = 27k - 9k + 3 + 1$ $18k = 6$ $k = \frac{1}{3}$
Obtains a fully correct expression for v ACF Coefficients can be unsimplified. Condone omission of constant	1.1b	A1	
Uses given initial conditions to find their constant of integration. This must be done **before** $v = 10$ and $t = 3$ are substituted.	3.4	M1	
Completes reasoned argument by substituting $v = 10$ and $t = 3$ into $v = kt^3 - kt^2 + t + 1$ to show $k = \frac{1}{3}$ Must include at least more one intermediate step after substituting. AG	1.1b	A1	
			Total 4 marks

Q3.

	Marking Instructions	AO	Marks	Typical Solution
(a)	Integrates given expression to find v with at least one term correct	3.4	M1	$v = \int a\,dt$ $= 3t + 0.1t^2 + c$ When $t = 2$, $v = k$ $k = 6 + 0.4 + c$ $c = k - 6.4$ $v = 3t + 0.1t^2 + k - 6.4$ Since $v = c$ when $t = 0$ the initial velocity is $k - 6.4$
	Obtains an expression for v with both terms correct condone omission of $+ c$	1.1b	A1	
	Substitutes $t = 2$ and $v = k$ into their integrated expression (must include constant of integration)	1.1a	M1	
	Completes rigorous argument with no slips to obtain $v = k - 6.4$ when $t = 0$	2.1	R1	

(b)	Forms equation using k, $k - 6.4$, and 0.2 or 5	3.1b	M1	$0.2k = k - 6.4$
	Obtains $k = 8$	1.1b	A1	$k = 8$
				Total 6 marks

Q4.

(a)

Marking Instructions	AO	Marks	Typical Solution
Integrates a to find v with at least one term correct	3.4	M1	$v = \int a\ dt$
Finds fully correct final expression Condone presence of + c	1.1b	A1	$v = 4t - t^3$
Subtotal		**2**	

(b)

Integrates v to find s with at least one term correct	3.1b	M1	$s = \int v\ dt$
Integrates their answer to (a) correctly including constant of integration	1.1b	A1F	$s = 2t^2 - \frac{1}{4}t^4 + k$
Uses given conditions to find constant	3.4	M1	$39 = 8 - 4 + k \Rightarrow k = 35$
Equates their expression for s to zero and finds a value for t	1.1a	M1	$0 = t^4 - 8t^2 - 140$
Obtains correct value of t to required accuracy	1.1b	A1	$t = 4.06$ seconds
Subtotal		**5**	

Question Total		**7**	